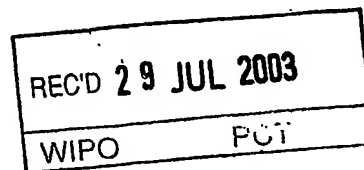


Rec. PCT/PTO 03 DEC 2004

407517068  
PCT/DK 03/00413



# Kongeriget Danmark

Patent application No.: PA 2002 00935

Date of filing: 19 June 2002

Applicant:  
(Name and address) NEG Micon A/S  
Alsvej 21  
8900 Randers  
Denmark

Title: Lightning Protection Means for a Wind Turbine

IPC: -

This is to certify that the attached documents are exact copies of the above mentioned patent application as originally filed.



Patent- og Varemærkestyrelsen  
Økonomi- og Erhvervsministeriet

08 July 2003

Pia Høybye-Olsen

## PRIORITY DOCUMENT

SUBMITTED OR TRANSMITTED IN  
COMPLIANCE WITH RULE 17.1(a) OR (b)

BEST AVAILABLE COPY

19 JUNI 2002

PVS

1

## LIGHTNING PROTECTION MEANS FOR A WIND TURBINE

## BACKGROUND OF THE INVENTION

- 5 The present invention relates to a wind turbine with lightning protection means, said means comprising means for conducting an electrical current induced by a lightning, said means capable of conducting the electrical current from blades of the wind turbine and to the nacelle of the wind turbine
- 10 Different kinds of means are known for protecting electrically fragile parts of wind turbines from lightning. One kind of means is intended for avoiding the electrical current from a lightning striking the blades of the wind turbine from entering the generator and other electrical and electronic components situated in the top of the wind turbine. This is done by conducting the electrical current from the blades to the tower of the wind turbine and to
- 15 the ground

- WO 01/86144 describes a wind turbine with such a lightning protection system. The lightning protection system comprises a rod mounted to the blades of the wind turbine. The stick is mounted at the base of the blades. The rod is intended as lightning conducting
- 20 means conducting the lightning from the base of the blades to a conducting ring mounted co-axially around the main shaft, outside the housing of the nacelle. From this conducting ring the electrical current is conducted through the machine carrying elements provided in the nacelle and further on to the tower along a slip means provided at the yawing gear. Thereby, the conducting of the electrical current is independent of the actual rotary
- 25 position of the machine carrying elements in the nacelle compared to the tower

- The apparatus described in the above WO-publication is said to be capable of ensuring that no electrical current from the lightning damages the electrical and electronic components. However, the invention is not so described as to enable the person skilled in the art to
- 30 obtain this object. Also, the means by which the lightning protection is provided has disadvantages. Firstly, providing a separate conducting ring outside and around the entire nacelle demands a very large ring and when mounted, though very difficult, inflicting the aerodynamic properties of the wind turbine nacelle. Also, how the large conducting ring is suspended in relation to the machine carrying elements of the nacelle is not described
- 35 Accordingly, the mounting of the conducting ring, which, as mentioned, is one of the major disadvantages of the apparatus, is not mentioned. Therefore, the person skilled in the art will not only be posed to the disadvantages apparent from the description, i.e. the large conducting ring, but will also have to apply a very inventive skill in order to overcome the problem of how to mount the large conducting ring

It is the object of the present invention to provide a lightning protection means for a wind turbine, said means providing for the necessary protection of the electrical and electronic components of the wind turbine, and being easy to install, both in the sense of the craftsman-like skills necessary, and also in sense of the components used, seeing that the lightning protection means is to be installed and serviced in the nacelle of the wind turbine, high above ground level or sea level

#### SUMMARY OF THE INVENTION

10

This object is obtained by a wind turbine lightning protection means, said means comprising electrical conductors passing from the base of the blades, through the hub and to the basis of the nacelle of the wind turbine by leading the electric conductors past the flange of the main shaft for mounting the hub to the shaft, and said electrical conductors  
15 being passed through the mounting flange electrically insulated from the mounting flange

By leading the electrical current along the electrical conductor through the hub, all of the lightning protection system will be kept within the boundaries of the hub, thus neither necessitating specially adapted means for suspending the lightning protection means to  
20 the hub or the nacelle, nor obstructing or impeding the aerodynamic properties of the wind turbine. However, passing the electrical conductors through the hub incur problems when having to pass the electrical conductors from the hub to the tower. This is accomplished by passing the electrical conductors either past the circumference of the mounting flange of the hub or by passing the electrical conductors through holes in the mounting flange

25

Passing the electrical current from the mounting flange to the nacelle may take place in any suitable manner. However, due to the fact that the mounting flange is rotating along with the main shaft and the hub, when the wind turbine is functioning, the present invention, in a preferred embodiment, makes use of special provisions for passing the  
30 electrical current from the mounting flange to a stationary part of the wind turbine

In a first embodiment, the electrically conducting member comprises an annular member provided around the main shaft of the wind turbine, and said annular member being electrically insulated from the mounting flange and from the main shaft, and where the  
35 annular member is attached to the mounting flange, thus rotating with the mounting flange, the main shaft and the hub, when the wind turbine are functioning, and where slip means are provided at a stationary part of the wind turbine compared to the hub mounting flange when rotating, said slip means conducting the electrical current from the annular member to the stationary part

In a second embodiment, the electrically conducting member comprises an annular member provided around the main shaft of the wind turbine, and said annular member being electrically insulated from the mounting flange and from the main shaft, and where  
5 the annular member is attached to a stationary part of the wind turbine compared to the mounting flange when rotating, thus not rotating with the mounting flange and the main shaft, when the wind turbine are functioning, and where slip means are provided at the mounting flange, said slip means conducting the electrical current from the mounting flange to the annular member

10

In principle, there is no difference in the individual parts and the function of the first embodiment and the second embodiment for passing the electrical current from the mounting flange to the tower via a stationary part of the wind turbine. The only difference is, whether the annular member is attached to the mounting flange and thus rotates along  
15 with the flange, when the wind turbine is functioning, with the contact pins being stationary, or whether the annular member in stead is mounted to the stationary part and thus the contact pins being attached to and rotating along with the mounting flange, when the wind turbine is functioning

20 The contact between the contact pins and the annular member may also be accomplished in different ways. One embodiment according to the invention makes use of metal brushes constituting the tip of the contact pins. A second embodiment makes use of carbon brushes constituting the tip of the contact pins, such as frequently used in electrical generators and electrical motors. A third and preferred embodiment makes use of a small  
25 gap between a pointed tip of the contact pins and the annular member, thus creating a small spark, when the current is led from the mounting flange to the stationary part.

An overall object of the different possible embodiments according to the invention for conducting the electrical current from the blades to the nacelle is to avoid electrical current  
30 being passed through sensitive parts and components in the nacelle. Thus, it is important to assure that parts such as bearings and components such as the generator will not be affected by the electrical current induced by the lightning and being passed to the nacelle

#### BRIEF DESCRIPTION OF THE DRAWINGS

35

The Invention will now be described with reference to the accompanying drawings, where

fig 1 is a perspective view of an embodiment of the lightning protection means according to the invention, also with other parts the wind turbine shown,

4

fig 2 is a perspective view of the embodiment viewed from the side and showing the pathway for the current when passing from the hub to the tower, and  
fig 3 is a perspective view of the embodiment viewed from the behind, also showing the pathway for the current when passing from the hub to the tower

5

#### DETAILED DESCRIPTION OF THE INVENTION

Fig 1 is a view showing parts of a wind turbine with lightning protection means being  
10 installed. The parts of the wind turbine are a nacelle 1 being in connection with a tower (not shown) of the wind turbine, a main shaft 2, a front bearing 3 for the main shaft, and a mounting flange 4 constituting a part of the main shaft, and for mounting a hub (not shown) to the front end of the main shaft. The bearing 3 is secured to the nacelle 1.

15 The lightning protection means comprises electrical conductors 5 intended for passing inside the shelf of the hub, insulating sleeves 6 intended for passing the electrical conductors through specially adapted holes 7 (see fig 2) in the mounting flange and an annular member 8 (see fig 2) being attached to the mounting flange by means of bushings 9 (see fig 2) and intended for rotating with the mounting flange when the wind  
20 turbine is functioning.

Thus, the electrical conductors lead from the base of the blades (not shown) of the wind turbine, into the hub (not shown) into the specially provided holes 7 in the mounting flange and to the annular member 8 attached to the opposite side of the mounting flange,  
25 namely the rear side of the mounting flange, compared to the front side of the mounting flange, onto which front side the hub is mounted by means of the mounting holes shown provided in the outer vicinity of the circumference of the mounting flange.

In an alternative embodiment, the electrical conductors do not pass through holes in the  
30 mounting flange, but pass the circumference of the mounting flange so that specially provided holes need not be provided in the mounting flange.

Fig 2 and fig. 3 are close-up views seen substantially from the side and seen from the rear, respectively, of how the lightning protection means is placed in relation to each other  
35 and in relation to the parts of the wind turbine. As mentioned above, the electrical conductors 5 pass from the hub (not shown) through the specially provided holes 7 in the mounting flange 4. As mentioned, electrically insulating sleeves (see fig 1) are provided in the holes 7 for electrically insulating the electrical conductors 5 from the mounting flange.

5

4 However, if the electrical conductors themselves are provided with insulation thick enough, the electrically insulating sleeves may be omitted

In the embodiment shown, three electrical conductors are shown, one from each blade of a conventional wind turbine, and three corresponding holes are provided in the mounting flange. However, wind turbines having another number of blades may be provided with another number than three electrical conductors and corresponding holes. However, wind turbines having three blades may nevertheless have all three blades connected to one and the same conductor passing through only one hole in the mounting flange

10

When the electrical conductors 5 have passed the mounting flange 4 through the holes 7, the electrical conductors are passed to the annular member 8. The annular member is electrically insulated from the mounting flange by being attached to the mounting flange using electrically insulating bushings 9 establishing a certain axial distance between the mounting flange and the annular member. Opposing the annular member, a number of contact pins 10 are provided

The contact pins 10 are mounted in a ring 11 being electrically in contact with the basis of the tower, i.e. the ground of the sea, either along the tower itself or along wires leading through the tower to the basis. The electrical contact may be provided through the bearing 3 for the main shaft 2, or it may be provided separate from the bearing. The number of contact pins is arbitrary. The contact pins have a pointed tip, and a small gap (not shown) is provided between the pointed tip of the contact pins and the annular member. The size of the gap depends on the number of contact pins and depends on the size of electrical current, which is expected during lightning, or which is intended for being conducted from the blades of the wind turbine and to the ground or sea. Preferably the size of the gap is between 1 mm and 10 mm, more preferably between 1 mm and 5 mm

In alternative embodiments, the current is passed from the annular member to the contact pins by means of metal brushes or carbon brushes constituting the tips of the contact pins instead of the pointed tip and abutting the annular member, thus passing the electrical current from the annular member to the contact pins without creating a spark

During lightning, the blades of the wind turbine may be struck by a lightning. The blades are provided with electrical conductors of commonly known type running along the lengths of the blades. The electrical conductors of the blades run to the base of the blades and the electrical current is passed to the electrical conductors constituting part of the present invention. The electrical current is then passed along the electrical conductors of the

invention from the base of the blade inside the hub, through the mounting flange and to the annular member

When the electrical current reaches the annular member, the electrical currents pass on to the tips of the contact pins by traversing the small gap as a spark running from the annular member to the tip of one or more contact pins. From the contact pins the electrical current is passed to the ground either through the bearing and perhaps through the metal of the tower, or through specially adapted means (not shown) for leading the current from the contact pins to the ground, perhaps along wires suspended in the tower

10

In an alternative embodiment, instead of the annular member being attached to the mounting flange and the contact pins being secured to the stationary part, the contact pins may be attached to the mounting plate and the annular member secured to the stationary part. Thus, instead of the annular member rotating with the mounting flange, the contact pins will be rotating with the mounting flange. However, the function of the contact pins and the annular member will be exactly the same, also if the contact pins are provided with metal brushes or carbon brushes at the tips instead of being pointed for creating a spark gap

15

## CLAIMS

1. A wind turbine lightning protection means, said means comprising means for conducting an electrical current induced by a lightning, said means capable of conducting the electrical  
5 current from blades of the wind turbine and to the basis of the wind turbine, and said means comprising electrical conductors passing from the base of the blades, through the hub and to the nacelle of the wind turbine by leading the electric conductors past the flange of the main shaft for mounting the hub to the shaft, and said electrical conductors being passed through the mounting flange electrically insulated from the mounting flange  
10
2. A wind turbine lightning protection means according to claim 1, where the electrically insulated leading of the electrical conductors past the mounting flange are provided by passing the electrical conductors past the circumference of the mounting flange and by providing insulation between the electrical conductors and the circumference of the  
15 mounting flange
3. A wind turbine lightning protection means according to claim 1, where the electrically insulated leading of the electrical conductors past the mounting flange are provided by passing the electrical conductors through holes in the mounting flange and by providing  
20 insulation between the electrical conductors and the holes in the mounting flange
4. A wind turbine lightning protection means according to any of the preceding claims, where the electrically conducting member comprises an annular member provided around the main shaft of the wind turbine, and said annular member being electrically insulated  
25 from the mounting flange and from the main shaft
5. A wind turbine lightning protection means according to claim 4, where the annular member is attached to the mounting flange, thus rotating with the mounting flange, the main shaft and the hub, when the wind turbine are functioning, and where slip means are  
30 provided at a stationary part of the wind turbine compared to the hub mounting flange when rotating, said slip means conducting the electrical current from the annular member to the stationary part
6. A wind turbine lightning protection means according to claim 4, where the annular  
35 member is attached to a stationary part of the wind turbine compared to the mounting flange when rotating, thus not rotating with the mounting flange and the main shaft, when the wind turbine are functioning, and where slip means are provided at the mounting flange, said slip means conducting the electrical current from the mounting flange to the annular member



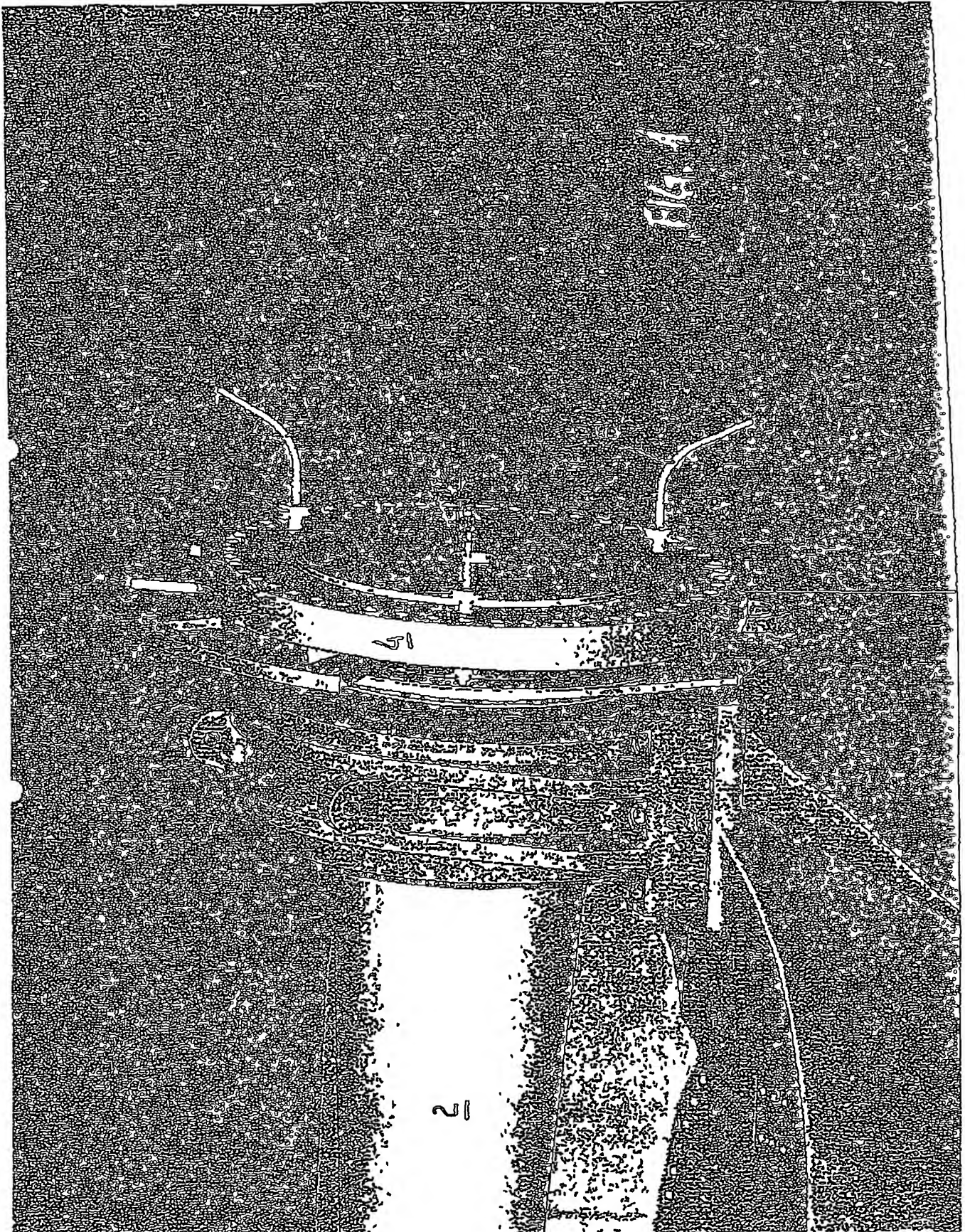
8

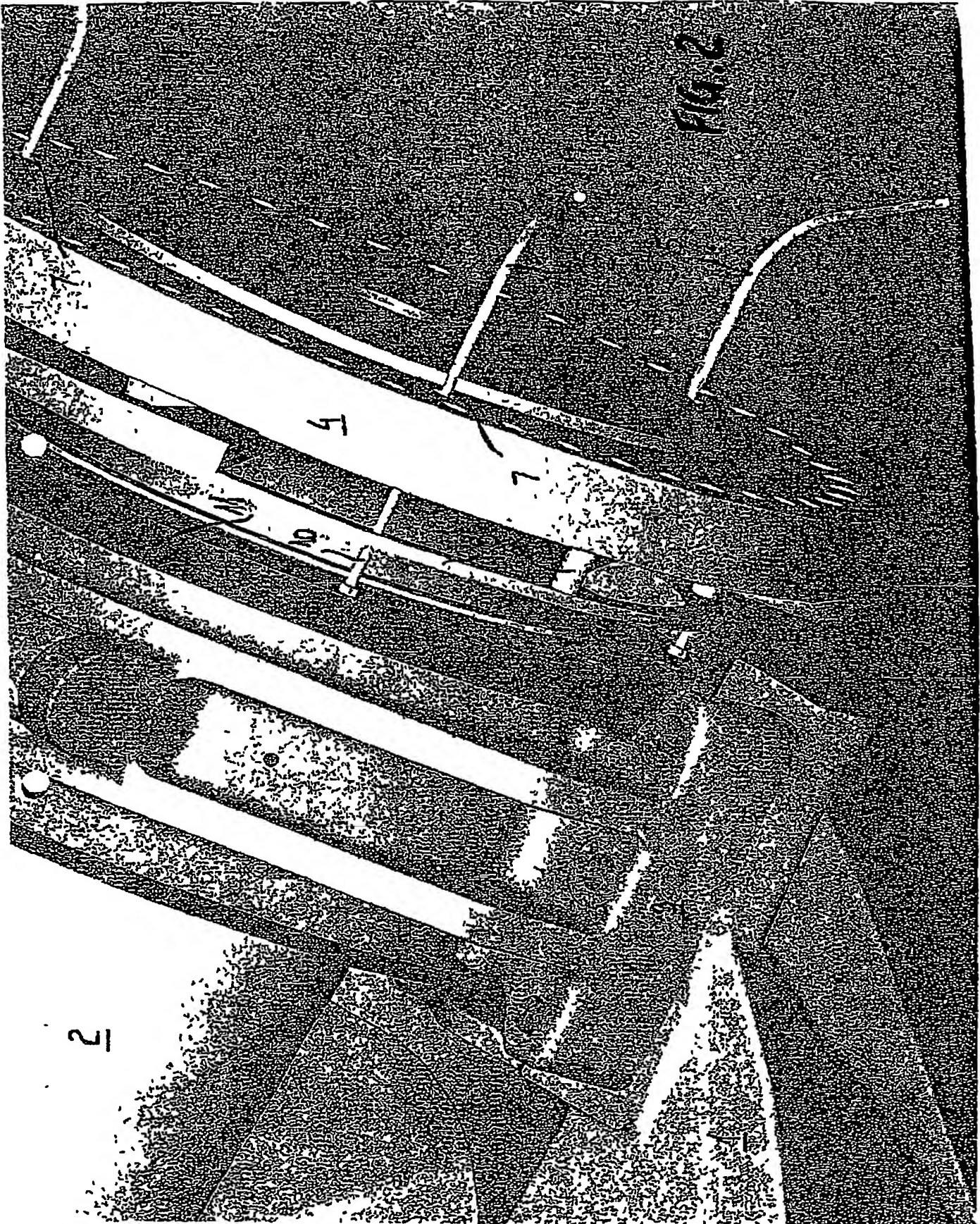
7 A wind turbine lightning protection means according to claim 5 or claim 6, where the slip means are a number of metal brushes abutting the annular member and sliding along the annular member, when the hub is rotating during functioning of the wind turbine

5

8 A wind turbine lightning protection means according to claim 5 or claim 6, where the slip means are a number of carbon brushes abutting the annular member and sliding along the member, when the hub is rotating during functioning of the wind turbine

- 10 9. A wind turbine lightning protection means according to claim 5 or claim 6, where the slip means are a number of gaps between the annular member and a tip of a number of contact pins, said gaps constituting spark gaps for the electrical current to pass between the annular member and the tip of the contact pins

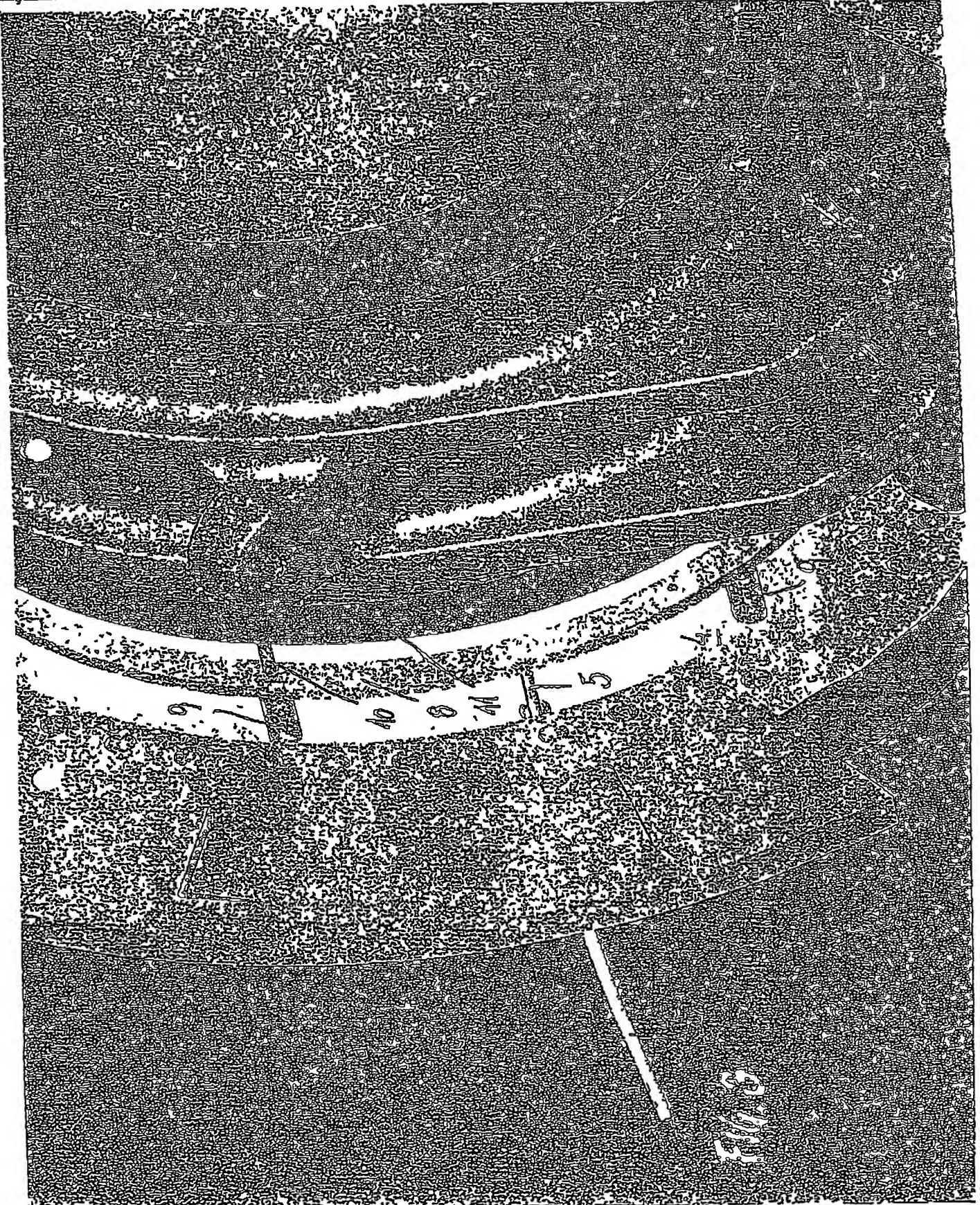




Modtaget

19 JUNI 2002





Modtaget

19 JUNI 2002

PVS

19/06 '02 13 23 FAX

Modtaget  
19 JUNI 2002  
PVS

001

Patent- og Varemærkestyrelsen  
Helgeshøj Alle 81  
2630 Taastrup

PR TELEFAX (1/14 sider)  
& POSTKOPI



Artikl. 8. om Sænkning

Denne meddelelse indeholder fornørlige oplysninger som kun er beregnet til brug for den person eller det firma der er nævnt ovenfor som modtager af meddelelsen. Såfremt De ikke er rette modtager af meddelelsen eller ansvarlig for at videregive denne til ovenfor angivne modtager er fotokopiering, arkivering eller videregivning af hele meddelelsen eller dele deraf i nogen form ikke tilladt. Hvis De fejlagtigt er modtager af denne meddelelse, bedes De straks underrette os herom pr. telefon eller telefaks. På forhånd tak.

19 juni 2002  
Ny dansk patentansøgning  
NEG Micon A/S  
Lynafleder  
Vores ref. 32267 DK 01

Vi vedlægger ny dansk patentansøgning **Lightning Protection Means for a Wind Turbine.**

Denne side	1 side
Ansøgningsdokument	2 sider
Beskrivelse	6 sider
Krav	2 sider
Tegninger	3 sider
I alt	14 sider

Original version sendes pr. postkopi.

Med venlig hilsen

Plougmann & Vingtoft A/S

  
Steen Iver Andersen

**Plougmann & Vingtoft**  
intellectual property consulting

Copenhagen  
Plougmann & Vingtoft a/s  
Sankt Annas Plads 11  
Post Office Box 1007  
DK 1021 Copenhagen K  
CVR No. 18 60 97 03  
Telephone +45 33 63 93 00  
Telefax +45 33 63 96 00  
e-mail pv@pv.dk  
www.pv.dk

Aarhus  
Plougmann & Vingtoft  
Årsgårdsvej  
Åboulevarden 23  
Post Office Box 49  
DK - 8100 Aarhus C  
Telephone +45 87 32 18 00  
Telefax +45 33 83 96 00  
e-mail pv@pv.dk  
www.pv.dk

A subsidiary of Intellectual Property  
holding is represented in  
Copenhagen Aarhus København  
Helsingborg Limburg Lund  
Malmö Göteborg Stockholm  
Munich Frankfurt Athens etc

**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

**BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☐ FADED TEXT OR DRAWING
- ☒ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☒ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☐ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: \_\_\_\_\_

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**